US006546523B1

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Boorananut et al.

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(54) **HIGH SPEED FIRST PASS YIELD REPORT PROGRAM AND METHOD**

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(51) **Int. Cl.**[7] **G06F 17/50**; G06F 15/167; G06F 15/00; H02H 3/05; G05B 9/02; G09G 5/00

(52) **U.S. Cl.** **716/4**; 716/1; 716/2; 716/10; 716/19; 714/38; 709/213; 700/82; 345/826; 707/526

(58) **Field of Search** 716/4

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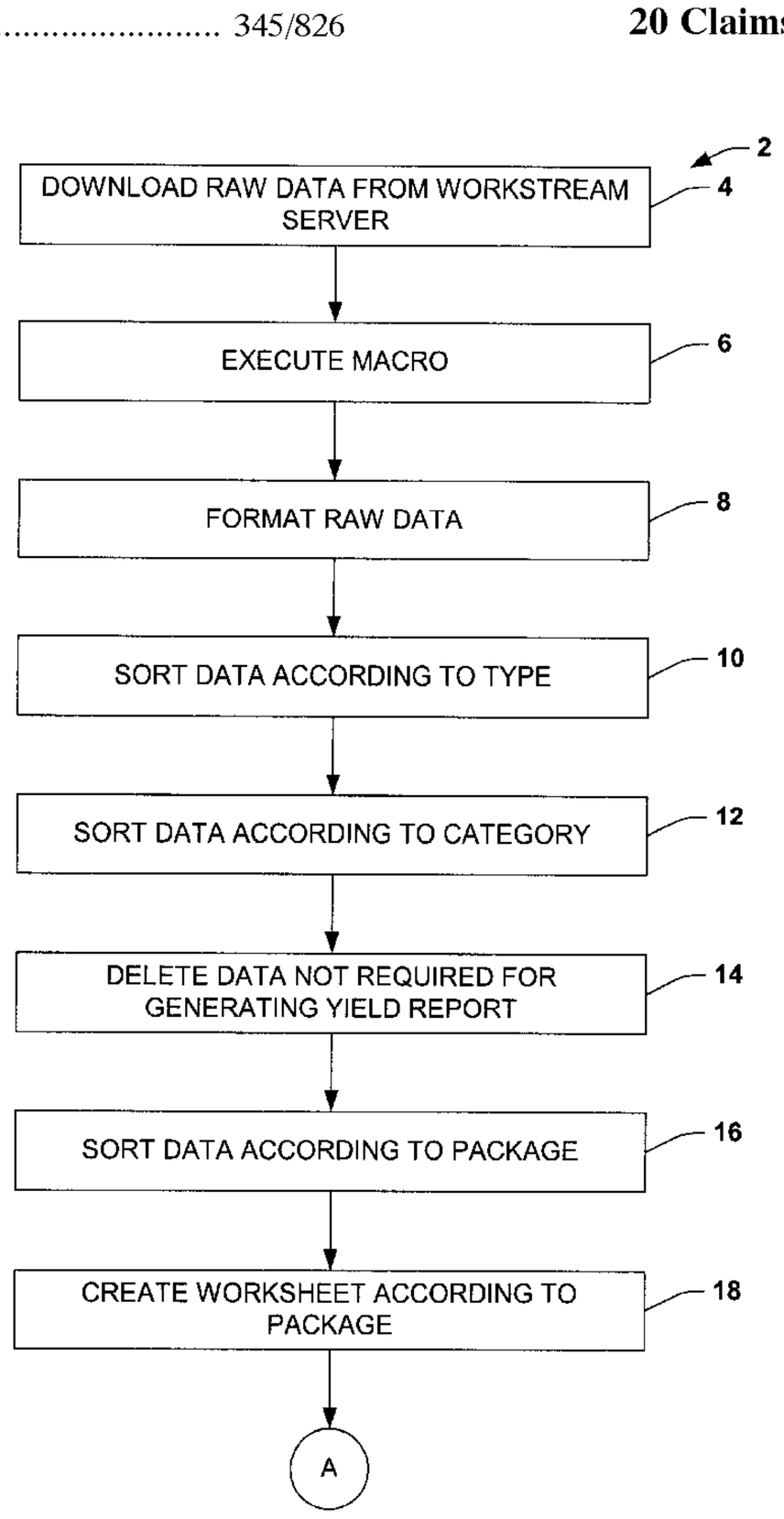
(57) **ABSTRACT**

A method and software macro are disclosed for generating a first pass yield report, which may be employed in the manufacture and testing of semiconductor products. The method comprises obtaining raw data from a workstream database, executing a software macro in a computer system, and generating a first pass yield report comprising final yield data calculated via the macro. The macro may comprise computer-executable instructions for formatting the raw data, sorting the formatted data, and calculating final yield data by package type.

20 Claims, 15 Drawing Sheets



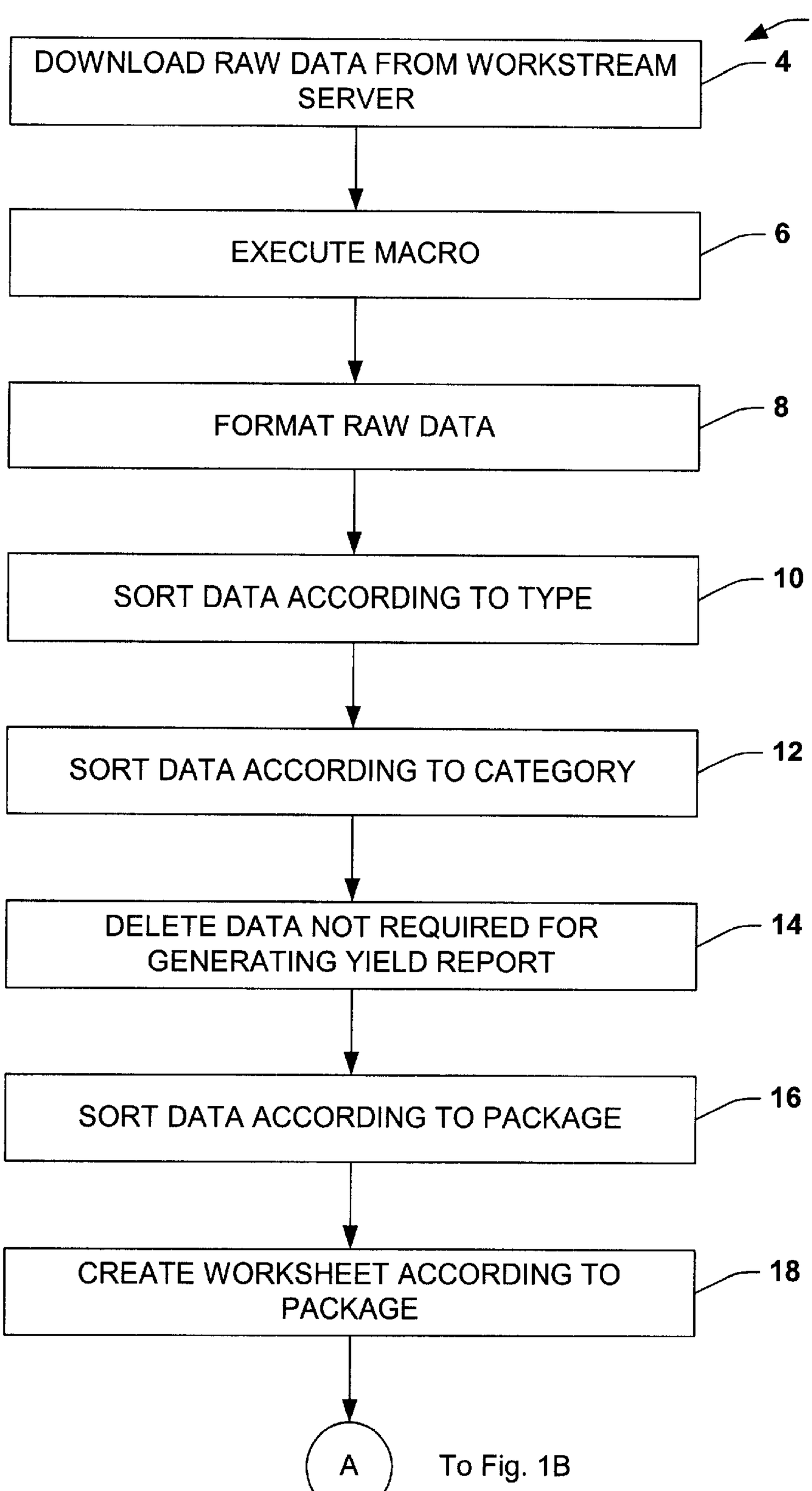

2
DOWNLOAD RAW DATA FROM WORKSTREAM SERVER
4
EXECUTE MACRO
6
FORMAT RAW DATA
8
SORT DATA ACCORDING TO TYPE
10
SORT DATA ACCORDING TO CATEGORY
12
DELETE DATA NOT REQUIRED FOR GENERATING YIELD REPORT
14
SORT DATA ACCORDING TO PACKAGE
16
CREATE WORKSHEET ACCORDING TO PACKAGE
18
A
To Fig. 1B

Fig. 1A

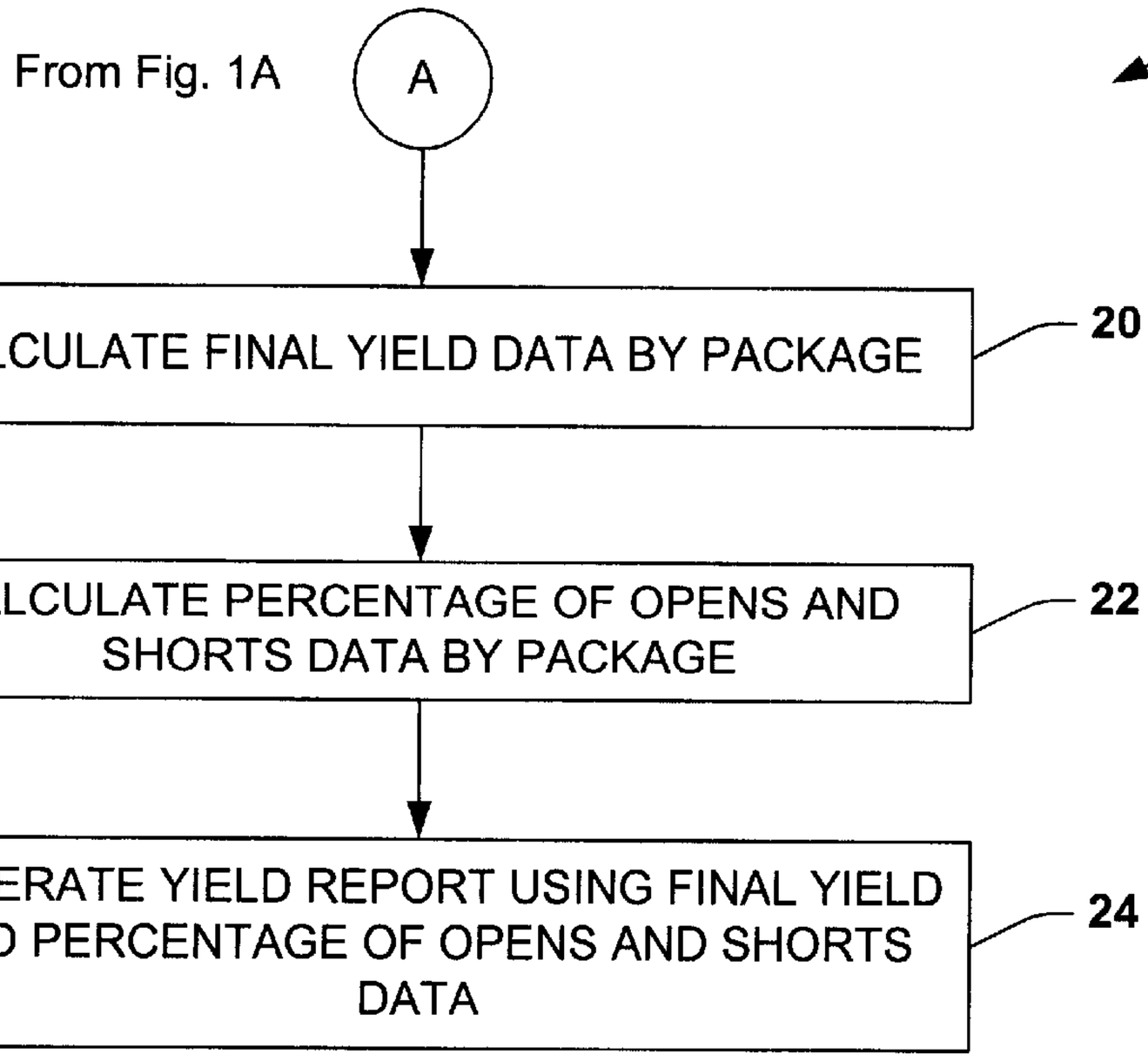

From Fig. 1A
A
2
CALCULATE FINAL YIELD DATA BY PACKAGE
20
CALCULATE PERCENTAGE OF OPENS AND SHORTS DATA BY PACKAGE
22
GENERATE YIELD REPORT USING FINAL YIELD AND PERCENTAGE OF OPENS AND SHORTS DATA
24

Fig. 1B

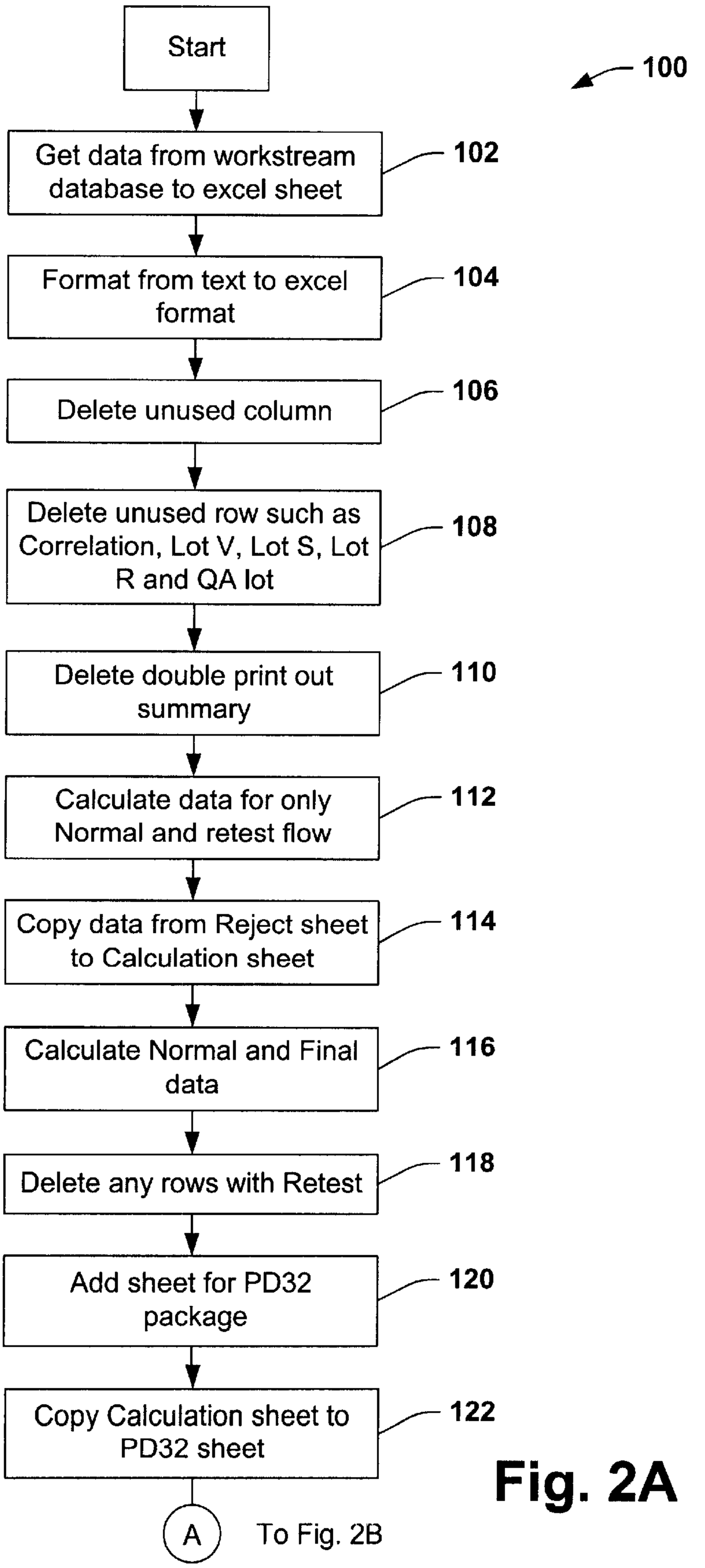

Start
100
Get data from workstream database to excel sheet
102
Format from text to excel format
104
Delete unused column
106
Delete unused row such as Correlation, Lot V, Lot S, Lot R and QA lot
108
Delete double print out summary
110
Calculate data for only Normal and retest flow
112
Copy data from Reject sheet to Calculation sheet
114
Calculate Normal and Final data
116
Delete any rows with Retest
118
Add sheet for PD32 package
120
Copy Calculation sheet to PD32 sheet
122
A
To Fig. 2B

Fig. 2A

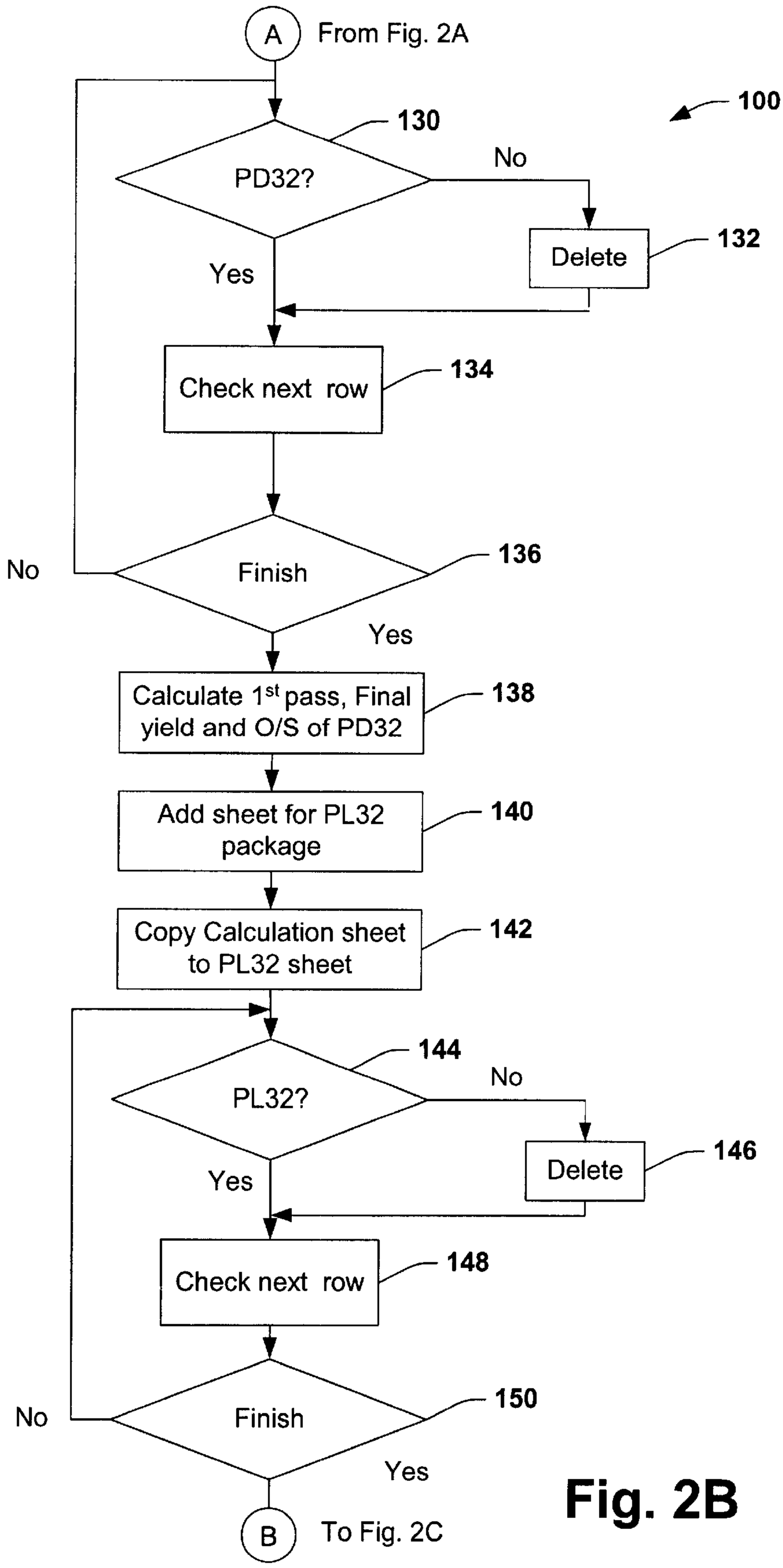

A
From Fig. 2A
100
130
PD32?
No
Yes
Delete
132
Check next row
134
Finish
136
No
Yes
Calculate 1st pass, Final yield and O/S of PD32
138
Add sheet for PL32 package
140
Copy Calculation sheet to PL32 sheet
142
144
PL32?
No
Yes
Delete
146
Check next row
148
Finish
150
No
Yes
B
To Fig. 2C

Fig. 2B

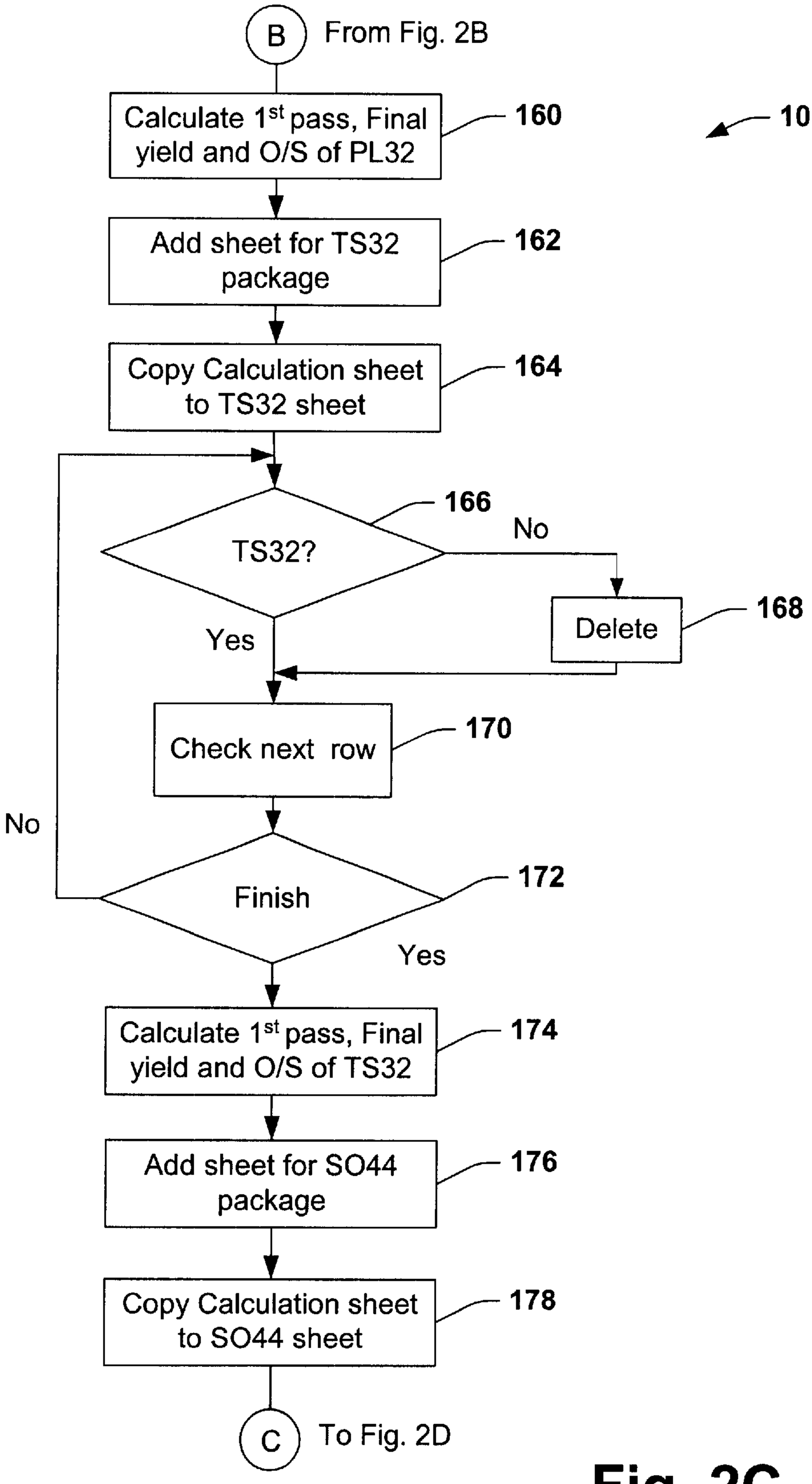

B
From Fig. 2B
Calculate 1st pass, Final yield and O/S of PL32
160
100
Add sheet for TS32 package
162
Copy Calculation sheet to TS32 sheet
164
166
TS32?
No
Yes
Delete
168
Check next row
170
No
Finish
172
Yes
Calculate 1st pass, Final yield and O/S of TS32
174
Add sheet for SO44 package
176
Copy Calculation sheet to SO44 sheet
178
C
To Fig. 2D

Fig. 2C

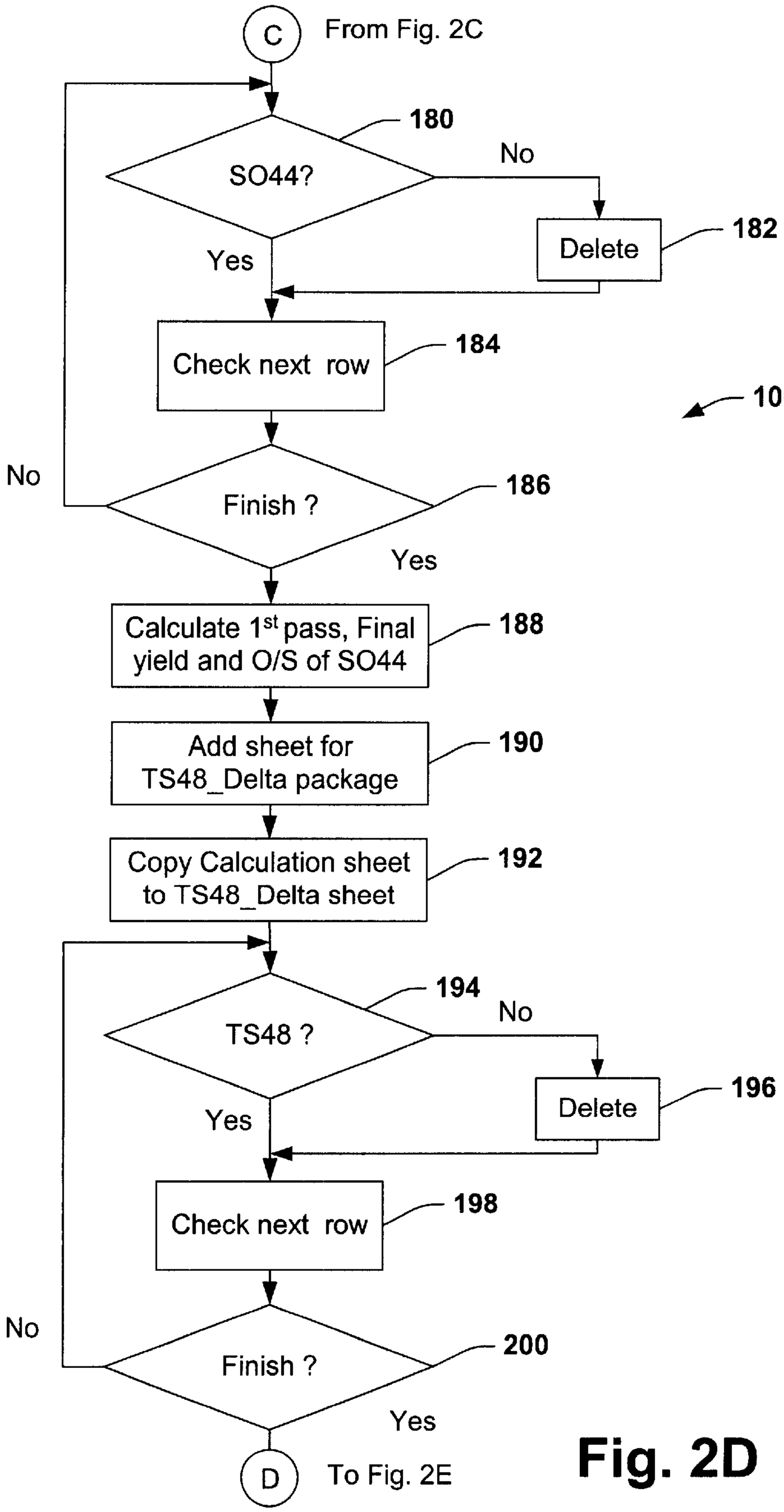

C
From Fig. 2C
180
SO44?
No
182
Delete
Yes
Check next row
184
100
No
Finish ?
186
Yes
Calculate 1st pass, Final yield and O/S of SO44
188
Add sheet for TS48_Delta package
190
Copy Calculation sheet to TS48_Delta sheet
192
194
TS48 ?
No
196
Delete
Yes
Check next row
198
No
Finish ?
200
Yes
D
To Fig. 2E

Fig. 2D

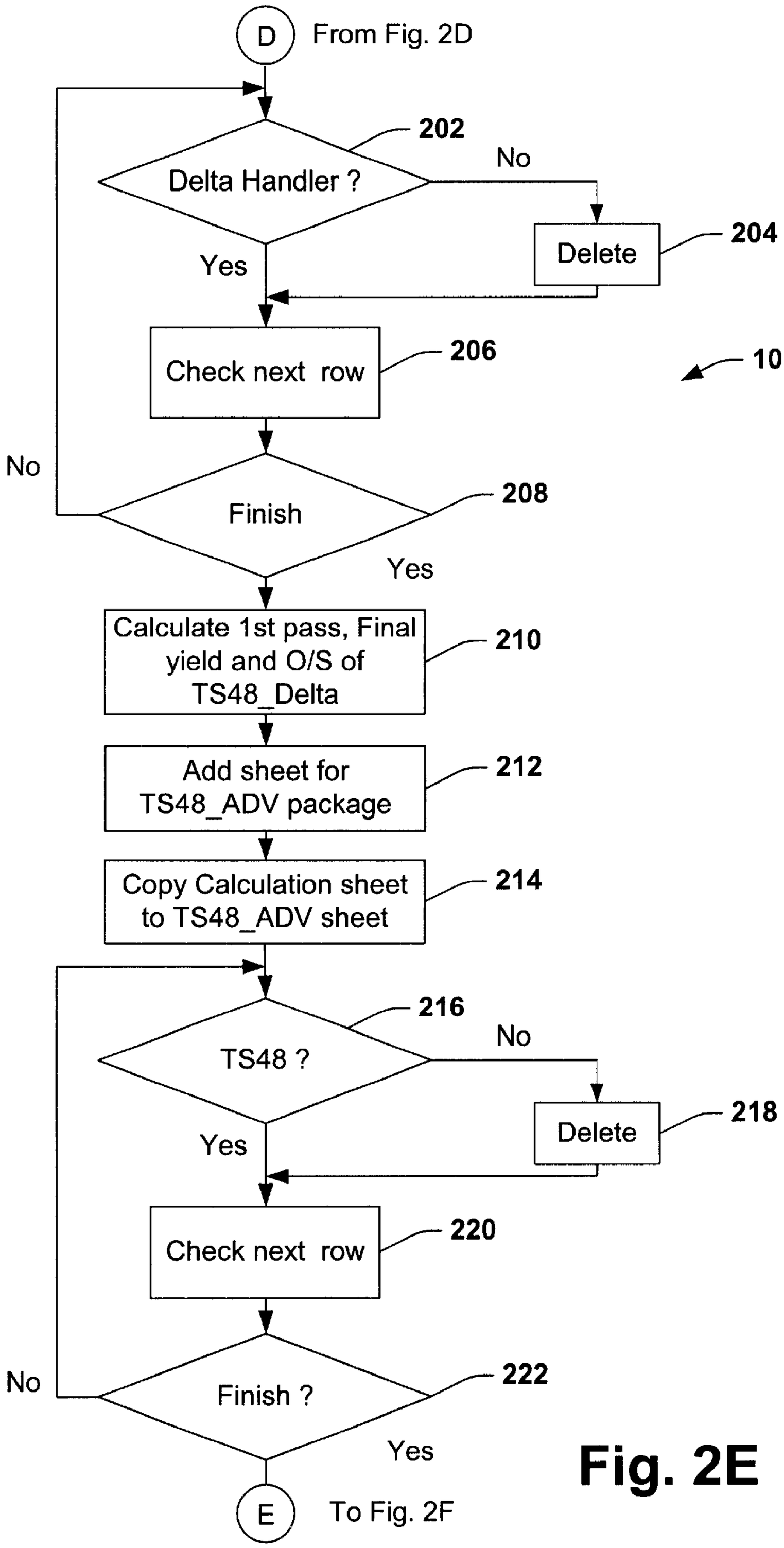

D
From Fig. 2D
202
Delta Handler ?
No
204
Delete
Yes
206
Check next row
100
No
208
Finish
Yes
210
Calculate 1st pass, Final yield and O/S of TS48_Delta
212
Add sheet for TS48_ADV package
214
Copy Calculation sheet to TS48_ADV sheet
216
TS48 ?
No
218
Delete
Yes
220
Check next row
No
222
Finish ?
Yes
E
To Fig. 2F

Fig. 2E

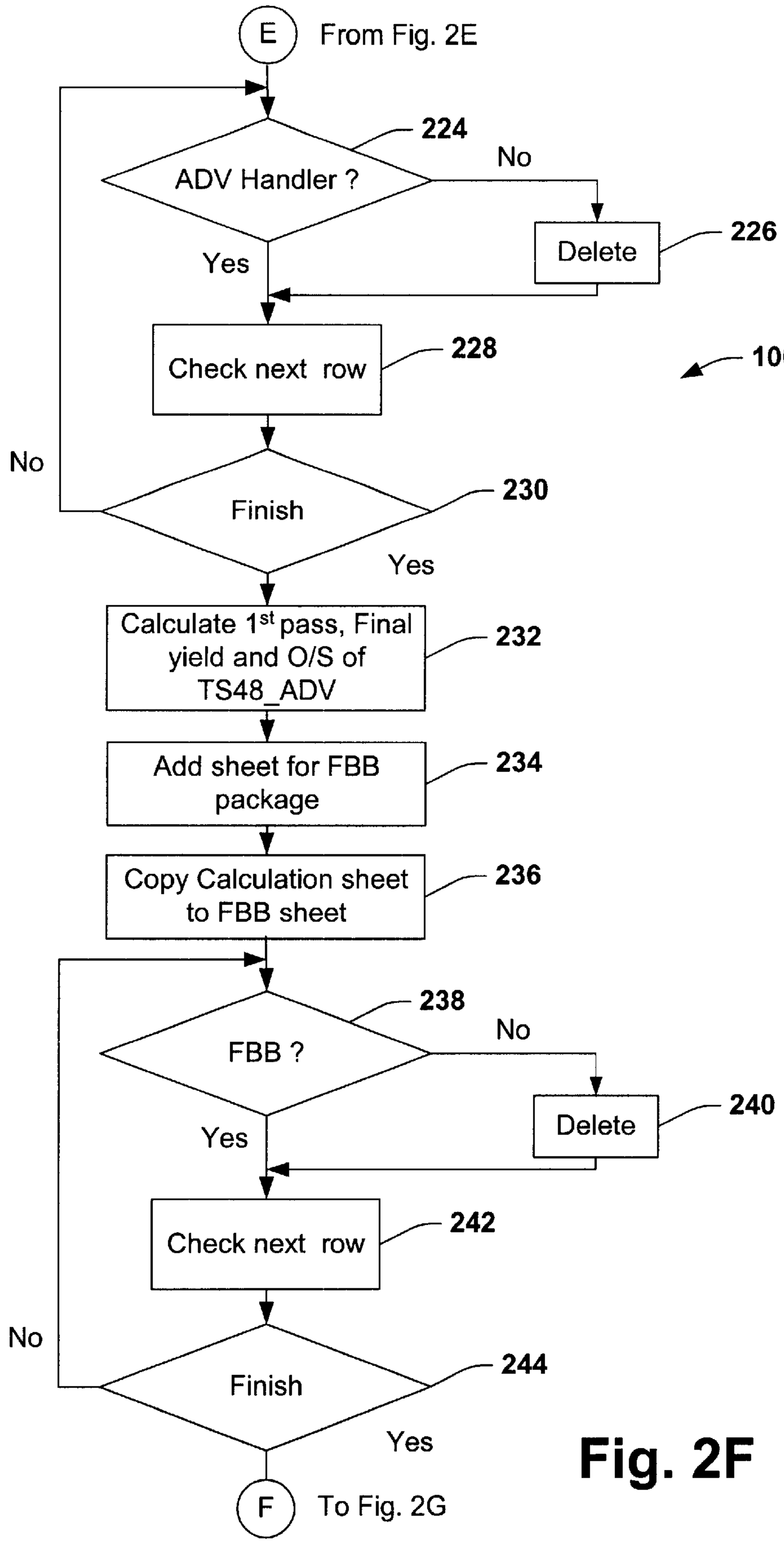

E
From Fig. 2E
224
ADV Handler ?
No
Yes
226
Delete
228
Check next row
100
No
230
Finish
Yes
232
Calculate 1st pass, Final yield and O/S of TS48_ADV
234
Add sheet for FBB package
236
Copy Calculation sheet to FBB sheet
238
FBB ?
No
Yes
240
Delete
242
Check next row
No
244
Finish
Yes
F
To Fig. 2G

Fig. 2F

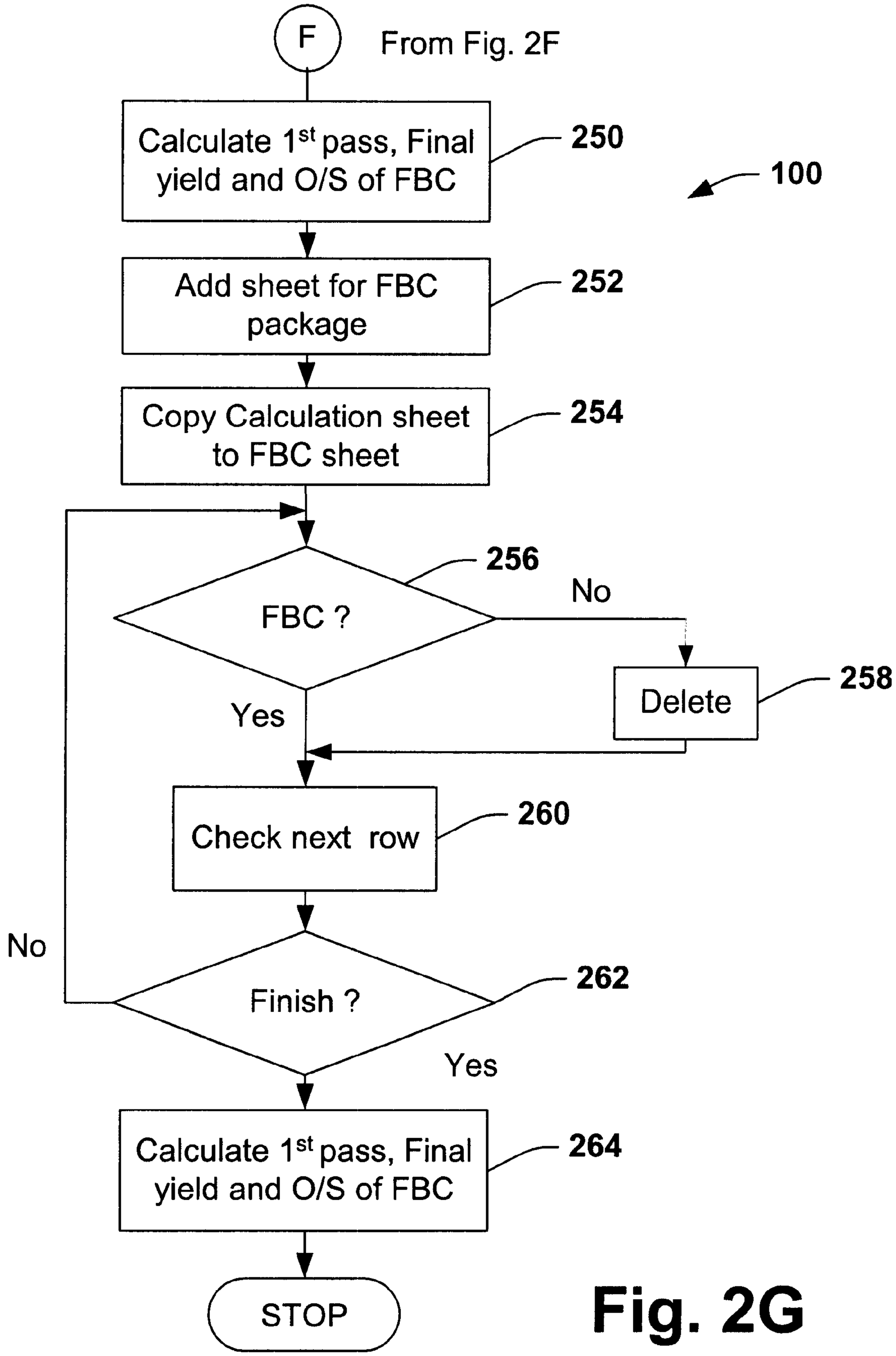

F
From Fig. 2F
Calculate 1st pass, Final yield and O/S of FBC
250
100
Add sheet for FBC package
252
Copy Calculation sheet to FBC sheet
254
256
FBC ?
No
Yes
Delete
258
Check next row
260
No
Finish ?
262
Yes
Calculate 1st pass, Final yield and O/S of FBC
264
STOP

Fig. 2G

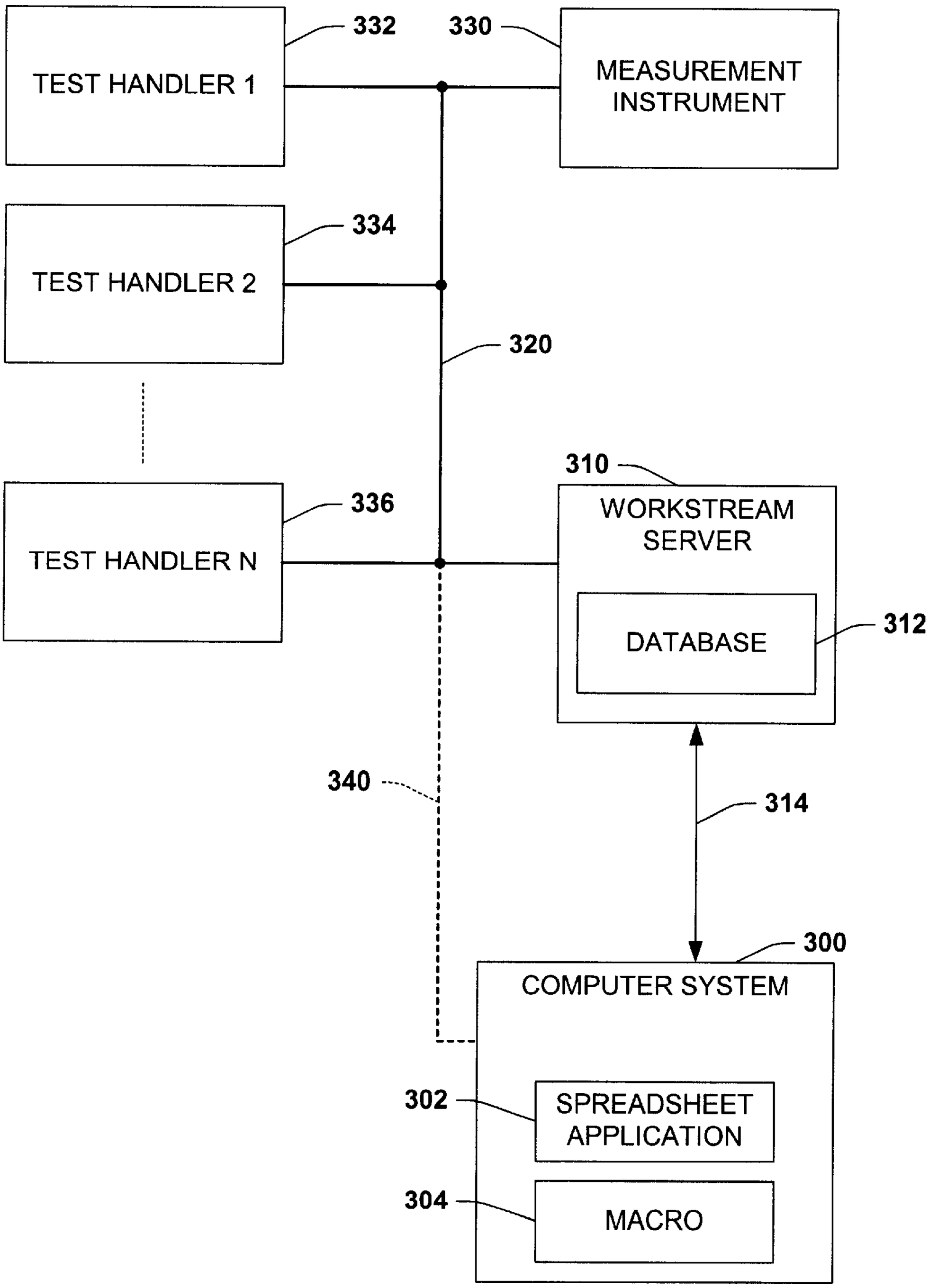

TEST HANDLER 1
332
330
MEASUREMENT INSTRUMENT
TEST HANDLER 2
334
320
TEST HANDLER N
336
310
WORKSTREAM SERVER
DATABASE
312
340
314
300
COMPUTER SYSTEM
302
SPREADSHEET APPLICATION
304
MACRO

Fig. 3

400

	A	B	C	D	E	F	G	H	I	J	K	L
714	5215830	RETEST	00/02/14	22:40:18	22:48:24	19	2	17	2	0	0	0
716	5215840	NORMAL	00/02/14	21:04:40	21:38:41	576	571	5	571	0	0	0
718	5215840	RETEST	00/02/14	21:43:25	21:52:18	9	3	2	3	0	0	0
720	5215860	NORMAL	00/02/13	10:54:10	0:01:12	10139	9923	216	9651	272	0	0
722	5215860	RETEST	00/02/14	0:05:33	1:08:08	216	86	130	86	0	0	0
724	5215870	NORMAL	00/02/14	5:31:18	14:08:59	12047	11688	359	11680	8	0	0
726	5215870	RETEST	00/02/14	14:14:14	15:12:54	359	218	141	218	0	0	0
728	5215970	NORMAL	00/02/14	6:03:06	10:30:08	16975	16802	173	5427	11374	1	0
730	5215970	RETEST	00/02/14	10:35:09	10:44:56	173	58	115	16	36	0	0
732	5215990	NORMAL	00/02/15	8:42:58	13:01:58	16491	16291	200	3859	12431	1	0
734	5215990	RETEST	00/02/15	13:08:06	13:21:15	200	90	110	24	66	0	0
736	5216000	NORMAL	00/02/15	2:59:05	8:22:40	19200	19025	175	4637	14398	0	0
738	5216000	RETEST	00/02/15	8:27:10	8:39:58	175	66	109	23	41	0	1
740	5216010	NORMAL	00/02/14	2:54:23	11:48:53	12012	11725	287	11709	16	0	0
742	5216010	RETEST	00/02/14	11:46:27	12:46:27	287	133	154	133	0	0	0
744	5216020	NORMAL	00/02/16	3:24:48	16:38:20	16574	14783	1791	14225	557	1	0
746	5216020	RETEST	00/02/16	16:45:56	21:26:43	1791	1113	678	1067	46	0	0
748	5216030	NORMAL	00/02/16	4:51:51	19:48:19	10969	10685	284	10631	53	1	0
750	5216030	RETEST	00/02/16	19:51:37	21:19:50	284	112	172	109	3	0	0
752	5216040	NORMAL	00/02/16	3:04:14	11:29:25	11974	11828	146	11791	37	0	0
754	5216040	RETEST	00/02/16	11:34:56	12:09:58	210	99	111	99	0	0	0
756	5216050	NORMAL	00/02/15	18:42:37	2:10:33	11057	10943	114	10830	113	0	0
758	5216050	RETEST	00/02/16	2:18:05	2:37:40	114	21	20	1	0	0	0

Fig. 4A

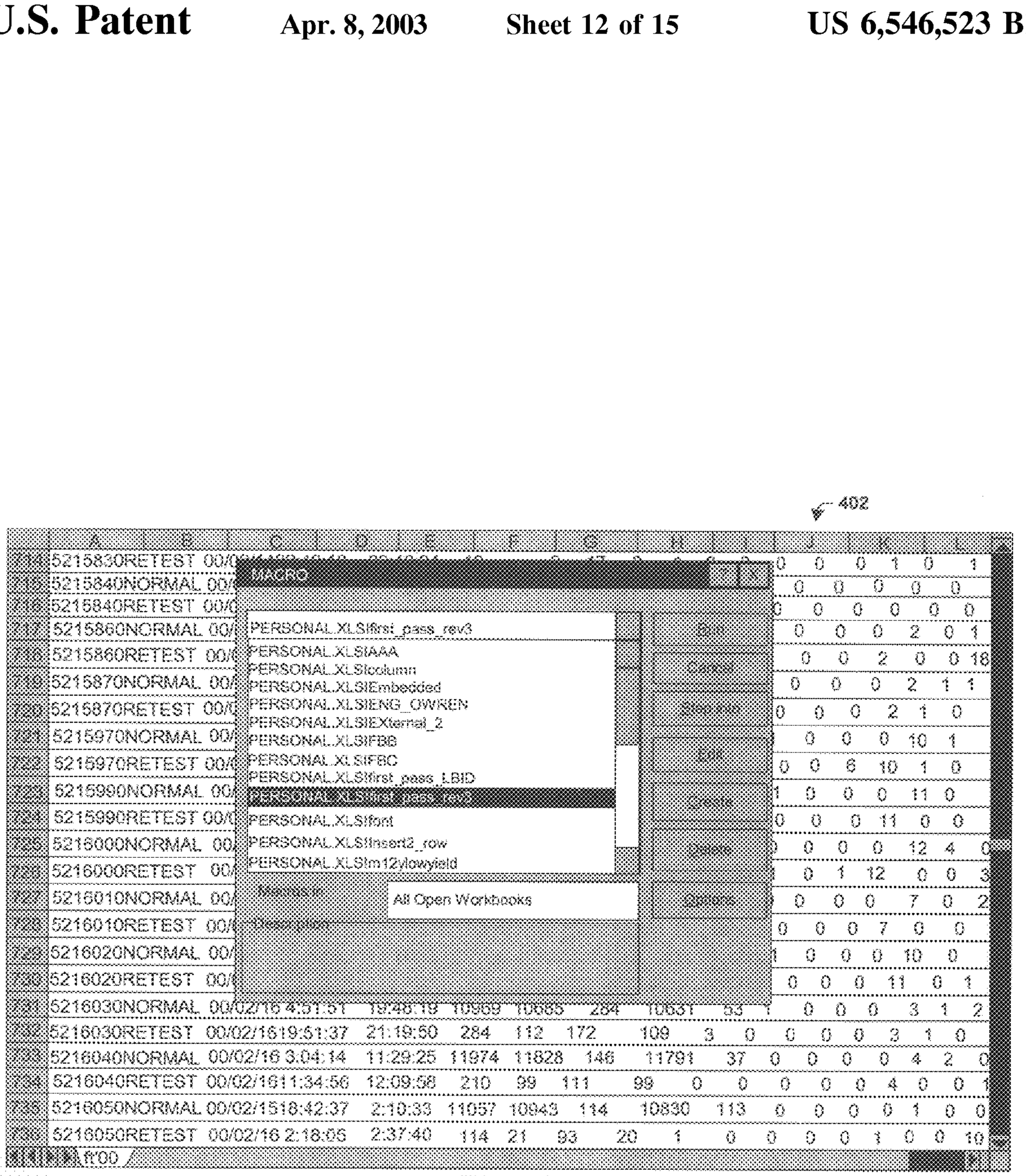

402
MACRO
PERSONAL.XLS!first_pass_rev3
PERSONAL.XLS!AAA
PERSONAL.XLS!column
PERSONAL.XLS!Embedded
PERSONAL.XLS!ENG_OWREN
PERSONAL.XLS!External_2
PERSONAL.XLS!FBB
PERSONAL.XLS!FBC
PERSONAL.XLS!first_pass_LBID
PERSONAL.XLS!first_pass_rev3
PERSONAL.XLS!font
PERSONAL.XLS!insert2_row
PERSONAL.XLS!m12lowyield
Macro in:
All Open Workbooks
Description
Run
Cancel
Step Into
Edit...
Create...
Delete...
Options...
5215830RETEST 00/
5215840NORMAL 00/
5215840RETEST 00/0
5215860NORMAL 00/
5215860RETEST 00/0
5215870NORMAL 00/
5215870RETEST 00/0
5215970NORMAL 00/
5215970RETEST 00/0
5215990NORMAL 00/
5215990RETEST 00/0
5216000NORMAL 00/
5216000RETEST 00/
5216010NORMAL 00/
5216010RETEST 00/0
5216020NORMAL 00/
5216020RETEST 00/0
5216030NORMAL 00/02/15 4:51:51 19:48:19 10969 10685 284 10631 53 1 0 0 0 3 1 2
5216030RETEST 00/02/1619:51:37 21:19:50 284 112 172 109 3 0 0 0 0 3 1 0
5216040NORMAL 00/02/16 3:04:14 11:29:25 11974 11828 146 11791 37 0 0 0 0 0 4 2 0
5216040RETEST 00/02/1611:34:56 12:09:58 210 99 111 99 0 0 0 0 0 0 4 0 0 1
5216050NORMAL 00/02/1518:42:37 2:10:33 11057 10943 114 10830 113 0 0 0 0 0 1 0 0
5216050RETEST 00/02/16 2:18:05 2:37:40 114 21 93 20 1 0 0 0 0 0 1 0 0 10
0 0 0 1 0 1
0 0 0 0 0
0 0 0 0 0 0
0 0 0 2 0 1
0 0 2 0 0 18
0 0 0 2 1 1
0 0 0 2 1 0
0 0 0 10 1
0 0 6 10 1 0
1 0 0 0 11 0
0 0 0 11 0 0
0 0 0 12 4 0
0 1 12 0 0 3
0 0 0 7 0 2
0 0 0 7 0 0
0 0 0 10 0
0 0 0 11 0 1
Ft'00

Fig. 4B

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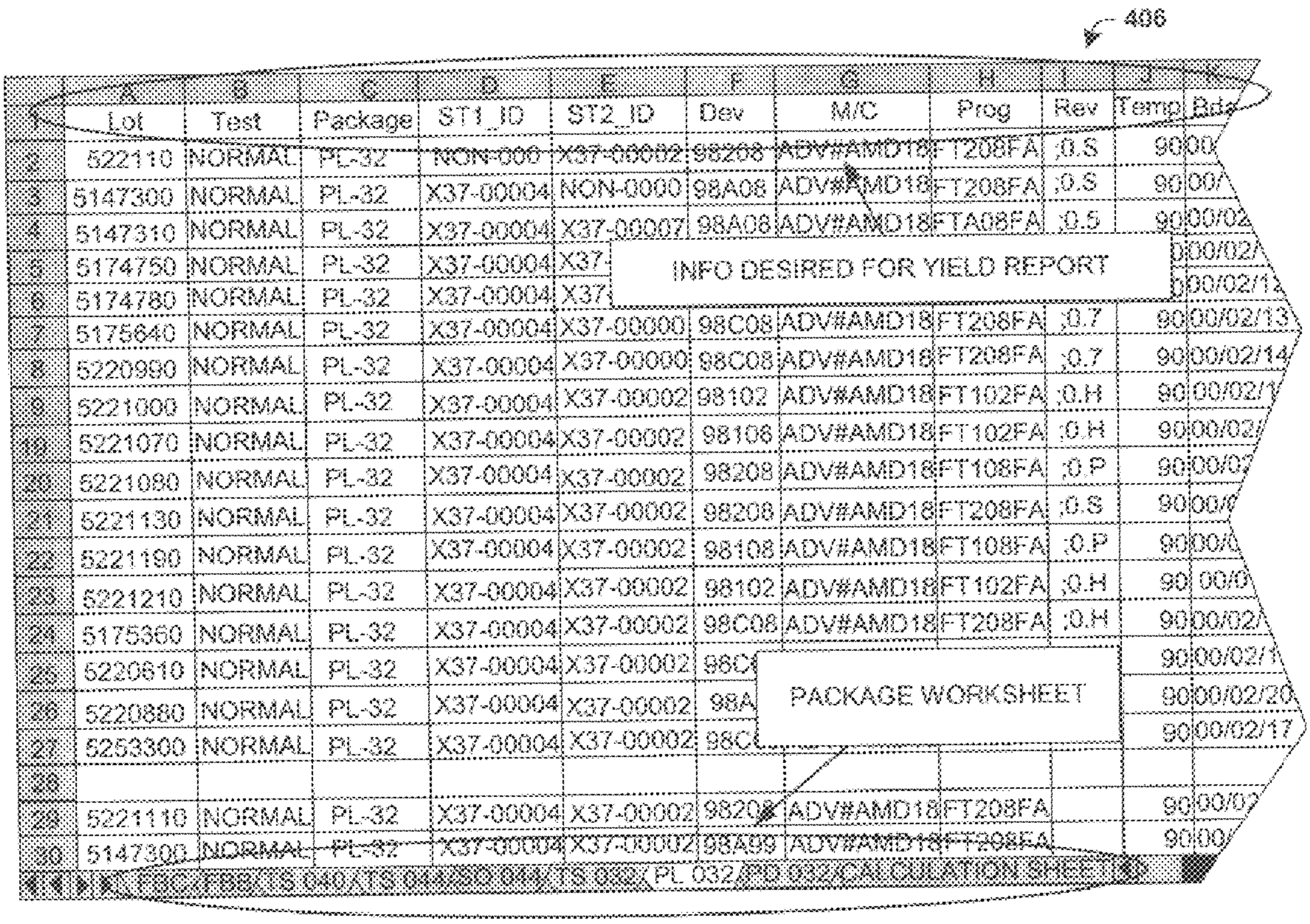
	A	B	C	D	E	F	G	H	I	J	K	L
27	5147300	NORMAL	00/02/07	11:02:56	12:00:40	3379	2753	626	2720	8	19	1
28	5147300	RETEST	00/02/07	12:07:20	12:13:02	43	67	510	86	0	2	0
29	5147310	NORMAL	00/02/07	12:22:19	13:05:15	5272	4397	875	4327	17	50	0
30	5147310	RETEST	00/02/07	14:50:55	15:00:06	60	139	705	137	1	1	0
31	Q954190	NORMAL	00/02/09	7:31:05	13:03:40	7206	5297	1909	5146	151	1	0
32	Q954190	RETEST	00/02/09	13:06:24	17:10:32	1913	1750	163	1748	2	0	0
33	5053650	NORMAL	00/02/10	5:32:53	7:37:45	23043	22589	454	20993	1493	35	10
34	5053650	RETEST	00/02/10	7:39:46	7:57:44	50	241	209	202	20	8	3
35	5179540	NORMAL	00/02/10	1:26:39	14:05:30	29889	26484	3405	26424	52	6	2
36	5179540	RETEST	00/02/10	14:13:22	17:57:14	1664	2881	278	2872	9	0	0
37	5218300	NORMAL	00/02/10	17:37:11	2:49:05	20291	19115	1176	2202	16582	0	323
38	5108910	RETEST	00/02/11	16:44:11	17:34:13	1092	1062	30	0	1061	1	0
39	5108910	NORMAL	00/02/11	17:38:28	17:43:07	30	27	3	0	27	0	0
40	5174750	RETEST	00/02/11	5:03:01	6:38:22	17704	16857	847	0	16351	499	5
41	5174750	NORMAL	00/02/11	15:30:17	16:02:01	838	727	111	0	710	17	0
42	5212870	RETEST	00/02/11	0:25:52	4:05:37	591	561	30	0	6	315	0
43	5218300	NORMAL	00/02/11	2:52:01	3:35:02	1184	767	417	21	716	0	22
44	5220490	RETEST	00/02/11	11:55:05	21:28:14	21422	21261	161	21260	0	1	0
45	5220490	NORMAL	00/02/11	21:33:01	21:44:57	254	179	75	179	0	0	0
46	5053660	RETEST	00/02/12	12:42:58	15:26:07	5482	5289	193	5113	172	2	2
47	5053660	NORMAL	00/02/12	15:31:58	15:48:01	193	178	15	170	8	0	0
48	5212630	RETEST	00/02/12	3:09:11	8:49:49	10049	3614	6435	3328	286	0	0
49	5215670	NORMAL	00/02/12	5:19:48	11:51:13	11189	3635	7554	3475	160	0	0

Fig. 4C



	A	B	C	D	E	F	G	H	I	J	K
1	Lot	Test	Package	ST1_ID	ST2_ID	Dev	M/C	Prog	Rev	Temp	Bda
2	522110	NORMAL	PL-32	NON-000	X37-00002	98208	ADV#AMD18	FT208FA	;0.S	90	00
3	5147300	NORMAL	PL-32	X37-00004	NON-0000	98A08	ADV#AMD18	FT208FA	;0.S	90	00/
4	5147310	NORMAL	PL-32	X37-00004	X37-00007	98A08	ADV#AMD18	FTA08FA	;0.5	90	00/02
5	5174750	NORMAL	PL-32	X37-00004	X37-						00/02/
6	5174780	NORMAL	PL-32	X37-00004	X37-						00/02/12
7	5175640	NORMAL	PL-32	X37-00004	X37-00000	98C08	ADV#AMD18	FT208FA	;0.7	90	00/02/13
8	5220990	NORMAL	PL-32	X37-00004	X37-00000	98C08	ADV#AMD18	FT208FA	;0.7	90	00/02/14
9	5221000	NORMAL	PL-32	X37-00004	X37-00002	98102	ADV#AMD18	FT102FA	;0.H	90	00/02/1
10	5221070	NORMAL	PL-32	X37-00004	X37-00002	98108	ADV#AMD18	FT102FA	;0.H	90	00/02/
11	5221080	NORMAL	PL-32	X37-00004	X37-00002	98208	ADV#AMD18	FT108FA	;0.P	90	00/0
12	5221130	NORMAL	PL-32	X37-00004	X37-00002	98208	ADV#AMD18	FT208FA	;0.S	90	00/
13	5221190	NORMAL	PL-32	X37-00004	X37-00002	98108	ADV#AMD18	FT108FA	;0.P	90	00/
14	5221210	NORMAL	PL-32	X37-00004	X37-00002	98102	ADV#AMD18	FT102FA	;0.H	90	00/0
15	5175360	NORMAL	PL-32	X37-00004	X37-00002	98C08	ADV#AMD18	FT208FA	;0.H	90	00/02/
16	5220610	NORMAL	PL-32	X37-00004	X37-00002	98C				90	00/02/1
17	5220880	NORMAL	PL-32	X37-00004	X37-00002	98A				90	00/02/20
18	5253300	NORMAL	PL-32	X37-00004	X37-00002	98C				90	00/02/17
19											
20	5221110	NORMAL	PL-32	X37-00004	X37-00002	9820	ADV#AMD18	FT208FA		90	00/0
21	5147300	NORMAL	PL-32	X37-00004	X37-00002	98A08	ADV#AMD18	FT208FA		90	00/

Fig. 4D-1

Rev	Temp	Bdate	Btime	EndTime	Qin	Qout	Yield	O/S Yield	Rej
;0.S	90	00/02/16	3:10:20	10:22:60	745	7339	98.47	0.09	11
;0.S	90	00/02/15	23:54:38	2:40:13	2535	2465	97.24	0.16	7
;0.4	90	00/02/18	5:51:59	[illegible]	[illegible]	[illegible]	[illegible]	.28	22
;0.4	90	00/02/18	15:59:42	[illegible]	[illegible]	[illegible]	[illegible]	.31	23
;0.P	90	00/02/17	8:16:18	14:40:20	15103	14746	97.43	0.96	38
;0.7	90	00/02/18	5:05:12	8:05:41	6325	6064	95.87	3.26	28
;0.4	90	00/02/18	10:26:17	15:14:42	5022	4861	96.79	1.12	18
;0.H	90	00/02/14	7:28:36	16:43:29	18013	17693	98.22	0.63	32
;0.H	90	00/02/15	4:06:09	14:52:05	20252	19800	97.77	0.58	45
;0.P	90	00/02/15	16:17:08	0:25:23	20104	19568	97.33	1.27	53
;0.S	90	00/02/18	19:49:51	4:21:57	8689	8423	96.94	0.71	26
;0.P	90	00/02/17	12:28:39	17:29:12	10046	9565	95.21	3.31	48
;0.H	90	00/02/17	18:22:47	4:19:11	20422	19851	97.2	1.68	57
;0.H	90	00/02/18	6:43:50	14:11:15	15229	14449	94.88	4.1	78
;0.H	90	[illegible]	[illegible]	[illegible]	15048	13948	92.69	4.28	110
:0.H	90	[illegible]	[illegible]	[illegible]	8170	7473	91.47	2.66	69
	90	[illegible]	[illegible]	[illegible]	5010	4668	93.17	2.75	34
				1ST PASS	319317	307341	96.25	1.41	1232
	90	00/02/16	1:19:22	11:20:02	8252	8139	98.63	0.19	11
	90	00/02/07	11:02:56	12:00:40	3379	2849	84.05	0.06	53

INFO DESIRED FOR YIELD REPORT

PACKAGE WORKSHEET

Fig. 4D-2

HIGH SPEED FIRST PASS YIELD REPORT PROGRAM AND METHOD

FIELD OF INVENTION

The present invention relates generally to semiconductor manufacturing, and more particularly to a program and method for generating a semiconductor test first pass yield report.

BACKGROUND OF THE INVENTION

In the semiconductor industry there is a continuing trend toward high line rate production of integrated circuit products. In order to achieve high quantity production as well as quality assurance, there have been, and continue to be, efforts toward providing automated testing of production parts as well as detailed analysis of test results. The production of semiconductor integrated circuits typically involves a multi-step manufacturing process in which defects or errors may be introduced into a product at one or more steps in the process. Manufacturing and process engineers study the defect rates and product yields as well as the efficiency associated with such multi-step manufacturing processes and the individual steps therein, in order to determine where changes in a process may improve the product, reduce cost, save time, and the like. In particular, the initial or first run of a given manufacturing process needs to be carefully scrutinized so that any necessary adjustments may be made prior to approving the process for further production.

Another trend in the semiconductor industry is the reduction of feature sizes and an increase in device density in integrated circuit products. Such features may include the width and spacing of interconnecting lines and the surface geometry such as the corners and edges of various features. The requirement of small features with close spacing between adjacent features requires high resolution photo lithographic processes. In general, lithography refers to processes for pattern transfer between various media. It is a technique used for integrated circuit fabrication in which, for example, a silicon wafer is coated uniformly with a radiation-sensitive film (e.g, a photoresist), and an exposing source (such as ultraviolet light, x-rays, or an electron beam) illuminates selected areas of the film surface through an intervening master template (e.g., a mask or reticle) to generate a particular pattern. The exposed pattern on the photoresist film is then developed with a solvent called a developer which makes the exposed pattern either soluble or insoluble depending on the type of photoresist (i.e., positive or negative resist). The soluble portions of the resist are then removed, thus leaving a photoresist mask corresponding to the desired pattern on the silicon wafer for further processing.

In addition to reduced feature sizes and device density increases, the introduction of larger and larger wafers makes defects in a single wafer potentially more costly than that of a smaller wafer. Thus, as more components may be included within a given high device density semiconductor wafer, and as the size of the wafers increases, the detection of manufacturing process defects becomes more critical. Accordingly, various inspection tools, such as those commercially available from KLA-Tencor, Orbot, and Inspex, have been developed to map and record wafer surface features and other defects. The timely and thorough analysis of test data obtained through such inspection equipment is important for quality assurance as well as for achieving and

maintaining high production rates for such high density semiconductor wafers.

Various testing instruments and equipment are typically employed in the manufacture of semiconductor devices, some of which may be made by different vendors. Each piece of test equipment makes measurements of specific features or performance indicia in the manufactured devices. For example, test equipment may be used to selectively verify shorts and opens between various nodes in an integrated circuit device. The correlation of the measured shorts and opens in a given die or device within a semiconductor wafer with those of a known good device may be used to indicate whether a device or circuit under test is defective. Where a batch of such devices is processed according to a multi-step manufacturing process, the yield of acceptable products may be advantageously monitored by production personnel in order to make necessary adjustments in one or more steps in the process in order to minimizing defects and down time.

Where a new or modified process is employed for the first time, the yield results may be closely scrutinized. However, the gathering of such first pass yield result data, and the sorting of such into useable form for engineering analysis takes time, during which the process may be continued (potentially at the risk of producing further defects), or the process may be interrupted pending data analysis. Thus, timely gathering, assembly, sorting, formatting, and calculation of such information is desirable. Heretofore, these tasks have been largely performed manually. For instance, process and manufacturing engineering personnel typically download individual sets of raw data from various test equipment into a spreadsheet computer software application. Thereafter, unwanted data is manually deleted, and sorting, reformatting, and computations are performed in order to present the yield results in a useable form for engineering analysis. Due to the increased cost of manufacturing down time, as well as the increased cost of high density semiconductor wafer defects, there remains a need for improved methods and systems for expeditiously generating yield reports.

SUMMARY OF THE INVENTION

The present invention provides a software macro or program and methodology for automated generation of yield reports. The invention finds particular utility in association with the manufacture and testing of semiconductor integrated circuits, although other applications are possible within the scope of the invention. The invention further includes a computer system for generating a yield report. According to one aspect of the invention, there is provided a method of generating a semiconductor manufacturing test first pass yield report, which comprises obtaining raw data from one or more workstream databases into a spreadsheet software application in a computer system, executing a software macro for formatting and sorting the raw data, as well as calculating final yield results, and generating a yield report including the calculated final yield data. The method may further comprise deleting data not required for generating the yield report, and calculating percentage of opens and shorts data by package, wherein generating a first pass yield report may further include using the calculated percentage of opens and shorts data.

According to another aspect of the invention, the macro may include computer-executable instructions for formatting the raw data, sorting the formatted data according to type and/or category, deleting data not required for gener-

ating the yield report, and sorting the remaining data according to device package type using the software macro. In addition, computer-executable instructions may be provided for creating at least one worksheet in the spreadsheet software application according to device package type using the software macro, calculating final yield data by package, and calculating percentage of opens and shorts data by package using the software macro. The data may be downloaded from one or more databases via a workstream server, and the deleted data may include quality assurance lot information, reliability lot information, returned lot information, correlation summary information, and unwanted test type information.

In accordance with still another aspect of the invention, there is provided a computer system for generating a semiconductor manufacturing test first pass yield report, which includes a spreadsheet software application, means for obtaining data from a workstream database, and a software macro having computer-executable instructions for formatting and sorting the data as well as calculating yield results.

Yet another aspect of the invention includes a software macro for generating a semiconductor manufacturing test first pass yield report in a computer system. The macro includes computer-executable instructions for formatting raw data from a workstream database, sorting the formatted data according to type, sorting the formatted data according to category, deleting data not required for generating the yield report, sorting the remaining data according to package, creating at least one worksheet in the spreadsheet software application according to package, calculating final yield and percentage of opens and shorts data by package. The macro may further include computer-executable instructions for generating a first pass yield report including the calculated final yield and percentage of opens and shorts data, and for providing calculated final yield and percentage of opens and shorts data for each worksheet. In addition, the macro instructions may provide for downloading the raw data from a workstream server or directly from one or more pieces of manufacturing test equipment, such as test handlers and the like.

To the accomplishment of the foregoing and related ends, the invention comprises the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative aspects and implementations of the invention. These are indicative, however, of but a few of the various ways in which the principles of the invention may be employed. Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a flow diagram illustrating an exemplary method of generating a semiconductor manufacturing test first pass yield report according to an aspect of the present invention;

FIG. **1**B is a flow diagram further illustrating the exemplary method of FIG. **1**A;

FIG. **2**A is a flow diagram illustrating another exemplary method of generating a semiconductor manufacturing test first pass yield report in accordance with the invention;

FIG. **2**B is a flow diagram further illustrating the exemplary method of FIG. **2**A;

FIG. **2**C is a flow diagram further illustrating the exemplary method of FIGS. **2**A–**2**B;

FIG. **2**D is a flow diagram further illustrating the exemplary method of FIGS. **2**A–**2**C;

FIG. **2**E is a flow diagram further illustrating the exemplary method of FIGS. **2**A–**2**D;

FIG. **2**F is a flow diagram further illustrating the exemplary method of FIGS. **2**A–**2**E;

FIG. **2**G is a flow diagram further illustrating the exemplary method of FIGS. **2**A–**2**F;

FIG. **3** is a schematic diagram illustrating an exemplary computer system in which various aspects of the invention may be carried out;

FIG. **4**A is an illustration of exemplary raw data downloaded from a workstream database into a spreadsheet software application in a computer system in accordance with an aspect of the invention;

FIG. **4**B is an illustration of an exemplary software macro being executed from within the spreadsheet application of FIG. **4**A according to the invention;

FIG. **4**C is an illustration of sorted and formatted data in the spreadsheet application of FIGS. **4**A and **4**B according to another aspect of the invention; and

FIG. **4**D is an illustration of an exemplary first pass yield report generated in a computer system according to the invention.

DETAILED DESCRIPTION OF THE INVENTION

The following is a detailed description of the present invention made in conjunction with the attached figures, wherein like reference numerals will refer to like elements throughout. The invention provides a software macro or program and methodology for generating yield reports in a useable form from raw data obtained from one or more test instruments and/or equipment. The invention advantageously employs the software macro in a computer system for obtaining, editing, sorting, formatting data from such devices, in addition to performing calculations and generating yield reports in a timely fashion. The macro may be implemented, for example, in a computer software application, such as a spreadsheet program, although other applications and implementations are contemplated as within the scope of the invention. In addition, while the following illustrations and description are provided with respect to the manufacture and testing of semiconductor products, the invention finds utility in other manufacturing endeavors as well.

Referring now to the drawings, FIGS. **1**A and **1**B illustrate an exemplary method **2** of generating a semiconductor manufacturing yield report in accordance with an aspect of the invention. The method may be performed, for example, in a computer system via a macro or other software program having computer-executable instructions for performing the various method steps. Beginning at step **4**, raw data is obtained or downloaded from a workstream server in to the computer system. As illustrated and described in greater detail hereinafter, the workstream server may be advantageously connected for communications with one or more pieces of test equipment used in the manufacture of semiconductor wafers, and may further include a workstream database having raw data therein. The data may be loaded, for example, into a spreadsheet or other software application program residing in the computer system. Thereafter at step **6**, a macro is executed, which may comprise computer-executable instructions for performing one or more tasks. The macro may be executed from within the software

application, or externally. In accordance with the macro instructions, the raw data is then formatted at step **8**, and sorted according to semiconductor device type and category at steps **10** and **12**, respectively.

Continuing at step **14**, unneeded data and other extraneous information may be deleted, which is not required for generating the desired yield report. For instance, the macro may delete quality assurance lot information, reliability lot information, returned lot information, correlation summary information, and unwanted test type information. The remaining data is then sorted at step **16** according to semiconductor device package type (e.g., PD32, PL32, TS32, SO44, TS48, FBB, and FBC package types). At step **18**, one or more worksheets (e.g., spreadsheet worksheet entities) are created, which may correspond to the device package types.

As illustrated further in FIG. **1**B, the method **2** proceeds at step **20** wherein final yield results or data are calculated by package type. In addition, the percentage of opens and shorts data may be calculated at step **22** by device package type. Finally, at step **24**, the desired yield report is generated, which includes the final yield and percentage of opens and shorts data calculated at steps **20** and **22**, respectively. The exemplary method **2** thus performs useful tasks formerly done manually, which provide manufacturing and process personnel and engineers with relevant report information in a timely fashion. The invention thus reduces the time it takes to analyze process performance results, which is particularly important during first pass or initial production runs. The early availability of such yield results allows the process to be continued after data analysis with minimal down time. In addition, the invention allows a first pass process to be run continuously with periodic report generation and analysis, whereby the risk of producing a large amount of defective product is minimized, due to the early availability of yield data reports.

Referring now to FIGS. **2**A–**2**G, another exemplary method **100** is illustrated in accordance with the present invention, which may be carried out, for example, in a computer system application program using a macro. In this regard, it will be appreciated that the invention further comprises a macro with computer-executable instructions for performing the steps of the exemplary methods **2** and **100**. Beginning at step **102**, raw test data is obtained from a workstream database (e.g., residing in a workstream server or other test equipment), which is then formatted at step **104** to conform to a spreadsheet software application program (e.g., excel, quattro). Unused columns may then be deleted at step **106** and unused or unnecessary rows may be deleted at step **108** (e.g., correlation information, lot information, and the like). In addition, double print out summary information may be deleted at step **110**, after which data may be calculated for normal tests and retests at step **112**.

Continuing at step **114**, data is copied from a reject sheet to a calculation sheet, after which normal and final data is calculated at step **116**. Retest rows are then deleted at step **118**. At step **120**, a worksheet is added for a PD32 package type, where after the calculation sheet to which data was copied at step **114** is copied to the PD32 worksheet at step **122**. Referring also to FIG. **2**B, the method **100** proceeds at step **130** wherein the first row in the PD32 worksheet is tested to determine whether the data therein relates to a PD32 package type device. If not, the row is deleted at step **132**, and if so, the next row is checked at step **134**. The method proceeds in this fashion through steps **130**, **132**, and **134** until it is determined at decision step **136** that all the data rows have been tested. Once all the rows have thus been tested and only those rows relating to the PD32 package type remain in the PD32 worksheet, the first pass final yield data and the percentage of opens and shorts data are calculated at step **138**.

A similar methodology is then applied at steps **140–160** with respect to PL32 device package type data. At step **140**, a worksheet is added for the PL32 device package type, to which the calculation sheet (step **114**) is copied at step **142**. Method **100** then proceeds through steps **144**, **146**, **148**, and **150** to delete data rows in the PL32 worksheet which do not include data for PL32 package type devices. Referring as well to FIG. **2**C, once all such data rows have been removed, the first pass final yield data and percentage data for opens and shorts are calculated for the PL32 package devices at step **160**.

Proceeding with steps **162–174** for the TS32 device package type, method **100** further includes adding a worksheet for TS32 package type data at step **162** and copying the calculation sheet to the TS32 worksheet at step **164**. Thereafter, the data rows in the TS32 worksheet are tested at step **166**, and those rows which have data for other package types are deleted at step **168**. Proceeding in this fashion through steps **166**, **168**, **170**, and **172**, until all rows have been tested, the method **100** continues at step **174** wherein the first pass final yield data and percentage data for opens and shorts are calculated for the TS32 package type devices.

At step **176**, a worksheet is added to the spreadsheet application for SO44 package type device data. The calculation sheet is then copied to the SO44 package worksheet at step **178**. Referring also to FIG. **2**D, the data rows in the SO44 package worksheet are then tested at decision step **180**, with rows having data for other package type devices being deleted at step **182**. Proceeding in this fashion through steps **180**, **182**, and **184**, the method **100** continues until all the data rows have been tested at step **186**. Thereafter, the first pass final yield and opens and shorts data are calculated at step **188**.

At this point it will be noted that the invention is applicable as well to manufacturing situations in which devices of a given package type are processed or tested in more than one piece of equipment, which may be from different vendors. For example, in the exemplary method **100**, provisions are made for generating separate yield report worksheets for devices of package type TS48 which are tested in Delta-flex brand test handler (e.g., steps **190–210**) as well as for TS48 devices tested in an Advantest brand test handler (e.g., steps **212–232**). In this regard, it will be appreciated that the invention is applicable to any number of test devices providing data, which may be connected in a network (e.g., local area network (LAN), or wide area network (WAN)), or which may otherwise be adapted to provide data for downloading to a computer system in which the methods and macros of the invention may be implemented.

Continuing at step **190**, a worksheet is added for TS48 package devices processed in a Delta handler, into which the calculation sheet is copied at step **192**. The rows of data in the TS48 Delta worksheet are then tested at steps **194** and **198**, whereby rows having data for devices other than TS48 devices from the Delta handler are deleted at step **196**. Proceeding in this fashion, decision step **200** determines that all rows have been checked. Thereafter, referring also to FIG. **2**E, the remaining data rows in the TS48 Delta package worksheet are again tested at steps **202** and **206**, with rows of data other than that generated in the Delta brand handler being deleted from the worksheet at step **204**. Once all such

data rows have been deleted at step **208**, the first pass yield and opens and shorts data is calculated at step **210** for the TS48 package devices processed in the Delta brand handler.

It will be appreciated that the steps **202**, **204**, and **206** are provided to include TS48 device package data for devices processed in the Delta brand test handler and to selectively exclude data for other than the Delta handler (e.g., TS48 package devices processed in an Advantest brand handler). In addition, those skilled in the art will appreciate that other methods and macros are conceivable within the scope of the invention to selectively include and/or exclude certain data according to the formatting and information configuration desired for a yield report.

The method **100** then continues in similar fashion at steps **212–232** with respect to TS48 package type devices processed in an Advantest brand test handler. Beginning at step **212**, a worksheet is added for TS48 devices processed in the Advantest handler, and the calculation sheet is copied thereto at step **214**. Thereafter, rows of data for other than TS48 package type devices are removed via steps **216**, **218**, **220**, and **220**, in similar fashion to steps described above. Referring also to FIG. **2**F, rows of data for other than devices processed in the Advantest handler are then removed via steps **224**, **226**, **228**, and **230**. First pass yield and shorts and opens data are then calculated at step **232** for the TS48 package devices processed in the Advantest handler.

The exemplary method **100** then continues at step **234** where a worksheet is added for FBB package type, where after the calculation sheet to which data was copied at step **114** is copied to the FBB worksheet at step **236**. At step **238** the first row in the FBB worksheet is tested to determine whether the data therein relates to an FBB package type device. If not, the row is deleted at step **240**, and if so, the next row is checked at step **242**. The method **100** proceeds in this fashion through steps **238**, **240**, and **242** until it is determined at decision step **244** that all the data rows in the FBB worksheet have been tested. Once all the rows have thus been tested and only those rows relating to the FBB package type remain, the first pass final yield data and the percentage of opens and shorts data are calculated at step **250** of FIG. **2**G.

At step **252**, a worksheet is added for a FBC package type, after which the calculation sheet is copied to the FBC worksheet at step **254**. Method **100** then continues at step **256** where the first row in the FBC worksheet is tested to determine whether the data in the row relates to an FBC package type device. If not, the row is deleted at step **258**, and if so, the next row is checked at step **260**. The method proceeds in this fashion through steps **256**, **258**, and **260** until it is determined at decision step **262** that all the data rows have been tested. Once all the rows have thus been tested and only those rows relating to the FBC package type remain in the FBC worksheet, the first pass final yield data and the percentage of opens and shorts data are calculated at step **264**.

The exemplary methods **2** and **100** illustrated and described above thus provide an efficient automated manner of obtaining raw data from a workstream database, executing a software macro in a computer system, including formatting the raw data, sorting the formatted data, and calculating final yield data by package. In addition the method automatically generates a first pass yield report including the calculated final yield data. However, it will be appreciated that other methods and macros are possible within the scope of the invention. The methods and macros according to the invention may be advantageously employed in a computer system in association with a software application program, such as a spreadsheet, although other implementations are possible. An exemplary system will hereinafter be described in which the invention may be practiced.

Referring now to FIG. **3**, an exemplary computer system **300** is illustrated, in which various aspects of the invention may be carried out. The computer system includes a spreadsheet software application program **302** and a software macro **304**, along with a processor, memory and user interface (not shown). The computer system **300** is adapted to interface with a workstream server **310** having a workstream database **312** via a communications medium **314** (e.g., RS232 connection, internet connection, network connection, and the like), whereby raw data (not shown) may be obtained or downloaded from the database **312** into the computer system **300** for processing according to the macro **304**.

The server **310** is connected via a network **320** to communicate with one or more pieces of test equipment, from which raw test data may be obtained and buffered in the database **312**. The network **320** may be any type of network (e.g., local area network (LAN), wide area network (WAN)) as are known, whereby the server may obtain such raw test data from a measurement instrument **330**, and/or one or more test handlers **332**, **334**, and **336**. As described above, the test handlers **332**, **334**, **336**, as well as the measurement instrument **330** may be of different vendor origin, providing raw test result data in disparate formats. The exemplary macro **304** as well as the methodologies described above may be adapted to compensate for the disparate data formatting from the test equipment in automatically generating final yield reports for analysis by manufacturing and other personnel, in accordance with the invention. In this regard, the data from individual pieces of test equipment (e.g., **330**, **332**, **334**, and/or **336**) may be provided thereby to the workstream server **310**, which then stores or buffers such data in the database **312** for subsequent downloading to the computer system **300** according to the macros and methodologies of the invention.

Although the server **310** may advantageously obtain data from the test equipment **330–336** for downloading to the computer system **300**, the computer system **300** may further be directly connected to the network **320** via connection **340**, or otherwise be adapted to communicate directly with one or more such pieces of test equipment. In this manner, raw test data may be obtained directly from the test equipment for processing and report generation according to another aspect of the invention. Moreover, the computer system **300** may be located remotely from the test equipment **330–336**, for example, using the internet or other remote access communications mediums for obtaining data therefrom. The use of the macro **304** for automatically obtaining, sorting, formatting, and editing such raw data, as well as calculating yield and other performance measures, provides significant time and cost savings over prior methods and systems, wherein manufacturing personnel would gather data from individual machines and perform such sorting, formatting, and computational tasks manually before yield analysis could begin.

Referring now to FIGS. **4**A–**4**D, an exemplary set of raw data **400** is illustrated, which may be obtained from one or more pieces of test equipment (e.g., **330–336** of FIG. **3**) in accordance with the invention. The data may be obtained, for example, via a download of such information from the database **312** of workstream server **310** to the spreadsheet software application program **302** of computer system **300**. In FIG. **4**B, a macro (e.g., macro **304** of FIG. **3**) may be

executed from within the spreadsheet application, for example, via a pop-up window user interface **402**. The macro then sorts and formats the raw data set **400** of FIG. **4**A, in order to obtain sorted and formatted data **404** in the spreadsheet application, as illustrated in FIG. **4**C. Thereafter, one or more first pass yield reports may be generated from the sorted and formatted data **404**, as illustrated in FIG. **4**D.

As shown, the report may include separate spreadsheet worksheets for individual device package types (e.g., PD32, PL32, TS32, SO44, TS48, FBB, and FBC package types), and may further separate similar package type data according to devices processed by different pieces of test equipment (e.g., TS48 package type devices processed in Delta and Advantest brand test handlers, as illustrated and described above). It will be appreciated that the macro may, but need not be executed from within another software application program, and further that many report styles and formats other than those specifically illustrated herein are possible and considered to fall within the scope of the present invention.

Although the invention has been shown and described with respect to one or more implementations, equivalent alterations and modifications will occur to others skilled in the art upon the reading and understanding of this specification and the annexed drawings. In particular regard to the various functions performed by the above described components (assemblies, devices, circuits, etc.), the terms (including a reference to a "means") used to describe such components are intended to correspond, unless otherwise indicated, to any component which performs the specified function of the described component (i.e., that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated exemplary implementations of the invention. In addition, while a particular feature of the invention may have been disclosed with respect to only one of several implementations, such feature may be combined with one or more other features of the other implementations as may be desired and advantageous for any given or particular application. Furthermore, to the extent that the term "includes" is used in either the detailed description and the claims, such term is intended to be inclusive in a manner similar to the term "comprising."

What is claimed is:

1. A method of generating a semiconductor manufacturing yield report, comprising:

downloading raw data from at least one workstream database into a spreadsheet software application in a computer system, wherein the downloading raw data from at least one workstream database comprises downloading the raw data from a workstream server;

executing a software macro in the computer system, comprising:

formatting the raw data using the software macro;

sorting the formatted data according to type using the software macro;

sorting the formatted data according to category using the software macro;

deleting data not required for generating the yield report;

sorting the remaining data according to package type using the software macro;

creating at least one worksheet in the spreadsheet software application according to package type using the software macro;

calculating final yield data by package type using the software macro; and

calculating percentage of opens and shorts data by package type using the software macro; and

generating the yield report comprising the calculated final yield and percentage of opens and shorts data.

2. The method of claim **1**, wherein deleting data not required for generating the yield report comprises deleting quality assurance lot information, deleting reliability lot information, deleting returned lot information, deleting correlation summary information, and deleting unwanted test type information.

3. The method of claim **1**, wherein generating the yield report comprises providing calculated final yield and percentage of opens and shorts data for each worksheet according to package type.

4. The method of claim **3**, wherein deleting data not required for generating the yield report comprises deleting quality assurance lot information, deleting reliability lot information, deleting returned lot information, deleting correlation summary information, and deleting unwanted test type information.

5. The method of claim **4**, wherein downloading raw data from at least one workstream database comprises downloading the raw data from a workstream server.

6. A computer system for generating a semiconductor manufacturing yield report, comprising:

a spreadsheet software application;

means for downloading raw data from at least one workstream database into the spreadsheet software application, the means for downloading raw data from at least one workstream database comprises means for downloading the raw data from a workstream server; and

a software macro having computer-executable instructions for:

formatting the raw data;

sorting the formatted data according to type;

sorting the formatted data according to category;

deleting data not required for generating the yield report;

sorting the remaining data according to package type;

creating at least one worksheet in the spreadsheet software application according to package type;

calculating final yield data by package type; and

calculating percentage of opens and shorts data by package type.

7. The computer system of claim **6**, wherein the software macro further comprises computer-executable instructions for generating a yield report comprising the calculated final yield and percentage of opens and shorts data.

8. The computer system of claim **7**, wherein the computer-executable instructions for generating the first pass yield report comprises computer-executable instructions for providing calculated final yield and percentage of opens and shorts data for each worksheet according to package type.

9. The computer system of claim **8**, wherein the computer-executable instructions for deleting data not required for generating the yield report further comprises computer-executable instructions for deleting quality assurance lot information, deleting reliability lot information, deleting returned lot information, deleting correlation summary information, and deleting unwanted test type information.

10. The computer system of claim **9**, wherein the means for downloading raw data from at least one workstream database comprises means for downloading the raw data from a workstream server.

11. The computer system of claim **6**, wherein the computer-executable instructions for deleting data not

required for generating the yield report further comprises computer-executable instructions for deleting quality assurance lot information, deleting reliability lot information, deleting returned lot information, deleting correlation summary information, and deleting unwanted test type information.

12. A software macro for generating a semiconductor manufacturing pass yield report in a computer system, comprising computer-executable instructions for:

formatting raw data from a workstream database;

sorting the formatted data according to type;

sorting the formatted data according to category;

deleting data not required for generating the yield report;

sorting the remaining data according to package type;

creating at least one worksheet in the spreadsheet software application according to package type;

calculating final yield data by package type; and

calculating percentage of opens and shorts data by package type;

wherein the computer-executable instructions for downloading raw data from at least one workstream database comprises computer-executable instructions for downloading the raw data from a workstream server.

13. The macro of claim **12**, further comprising computer-executable instructions for generating a yield report comprising the calculated final yield and percentage of opens and shorts data.

14. The macro of claim **13**, wherein the computer-executable instructions for deleting data not required for generating the yield report comprises computer-executable instructions for deleting quality assurance lot information, deleting reliability lot information, deleting returned lot information, deleting correlation summary information, and deleting unwanted test type information.

15. The macro of claim **13**, wherein the computer-executable instructions for generating the first pass yield report comprises computer-executable instructions for providing calculated final yield and percentage of opens and shorts data for each worksheet according to package type.

16. The macro of claim **15**, wherein the computer-executable instructions for downloading raw data from at least one workstream database comprises computer-executable instructions for downloading the raw data from a workstream server.

17. The macro of claim **12**, wherein the computer-executable instructions for deleting data not required for generating the yield report comprises computer-executable instructions for deleting quality assurance lot information, deleting reliability lot information, deleting returned lot information, deleting correlation summary information, and deleting unwanted test type information.

18. In a computer system, a method for generating a yield report, comprising:

obtaining raw data from a piece of test equipment comprising downloading the raw data from a workstream server;

executing a software macro in the computer system, comprising:

formatting the raw data;

sorting the formatted data; and

calculating final yield data by package type; and

generating the yield report comprising the calculated final yield data.

19. The method of claim **18**, further comprising deleting data not required for generating the yield report.

20. The method of claim **18**, further comprising calculating percentage of opens and shorts data by package type, wherein generating the yield report further comprises using the calculated percentage of opens and shorts data.

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